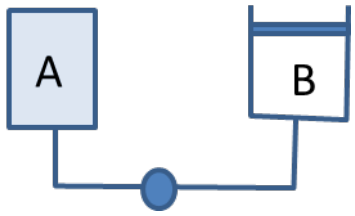
Tutorial sheet_6

Availability

1. A piston/cylinder arrangement B is connected to a 1-m3 tank A by a line and valve, shown in Fig. Initially both contain water, with A at 100 kPa, saturated vapor and B at 400°C, 300 kPa, 1 m3. The valve is now opened and, the water in both A and B comes to a uniform state.



a. Find the initial mass in A and B.
b. If the process results in $T2 = 200°C$, find the heat transfer and work. Calculate the reversible work and irreversibility for the process described in this assuming that the heat transfer is with the surroundings at 20°C. (10.1) Ans: 6.6 kJ, Irr=271.4kJ

2. A cylinder with a piston restrained by a linear spring contains 2 kg of carbon dioxide at 500 kPa, 400°C. It is cooled to 40°C, at which point the pressure is 300 kPa. Calculate the heat transfer for the process. Calculate the reversible work and the irreversibility for this process assuming the surroundings temp to be 20C. (10.2) w=195 KJ, I= 240.7kJ

3. An air compressor takes air in at the state of the surroundings 100 kPa, 300 K. The air exits at 400 kPa, 200°C at the rate of 2 kg/s. Determine the minimum compressor work input. (10.6) Ans: 312.73kW

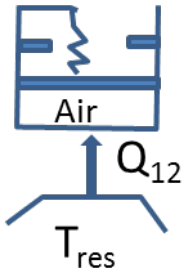
4. A steam turbine receives steam at 6 MPa, 800°C. It has a heat loss of 49.7 kJ/kg and an isentropic efficiency of 90%. For an exit pressure of 15 kPa and surroundings at 20°C, find the actual work and the reversible work between the inlet and the exit. (10.9) Ans: Wact= 1483.91, W-rev=1636.8

5. A flow of steam at 10 MPa, 550°C goes through a two-stage turbine. The pressure between the stages is 2 MPa and the second stage has an exit at 50 kPa. Assume both stages have an isentropic efficiency of 85%. Find the second law efficiencies for both stages of the turbine. (10.40) Ans: 0.918, 0 .871

6. Steam is supplied in a line at 3 MPa, 700°C. A turbine with an isentropic efficiency of 85% is connected to the line by a valve and it exhausts to the atmosphere at 100 kPa. If the steam is throttled down to 2 MPa before entering the turbine find the actual turbine specific work. Find the change in availability through the valve and the second law efficiency of the turbine. (10.44) Ans: 835.2 kJ, 0.91

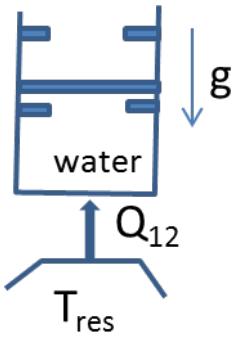
7. Air in a piston/cylinder arrangement is at 110 kPa, 25°C, with a volume of 50 L. It goes through a reversible polytropic process to a final state of 700 kPa, 500 K, and exchanges heat with the ambient at 25°C through a reversible device. Find the total work (including the external device) and the heat transfer from the ambient. (10.52) Ans: -9.58kJ

8. Air in a piston/cylinder arrangement, shown in Fig, is at 200 kPa, 300 K with a volume of 0.5 m^3. If the piston is at the stops, the volume is 1 m^3 and a pressure of 400 kPa is required to balance the piston. The air is then heated from the initial state to 1500 K by a 1900 K reservoir. Find the total irreversibility in the process assuming surroundings are at 20°C. (10.59) Ans: Irr =303.kJ, s_{gen}=1.034kJ/K



9. Water in a piston/cylinder is at 100 kPa, 34°C, shown in Fig. The cylinder has stops mounted so V_{min} = 0.01 m^3 and V_{max} = 0.5 m^3. The piston is loaded with a mass and outside P_0, so a pressure inside of 5 MPa will float it. Heat of 15000 kJ from a 400°C source is added. Find the total change in availability of the water and the total irreversibility.

(10.56) Ans: change in flow availability = 4448kJ, Irr = 3326 kJ



10. Air enters a steady-flow turbine at 1600 K and exhausts to the atmosphere at 1000 K. The second law efficiency is 85%. What is the turbine inlet pressure? (10.50) Ans: 3003kPa

11. A compressor is used to bring saturated water vapor at 1 MPa up to 17.5 MPa, where the actual exit temperature is 650°C. Find the irreversibility and the second-law efficiency. (10.39) Ans: Irr = 44.48kJ, 0.951